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WAVE, LONGSHORE CURRENT AND BEACH PROFILE RECORDS FOR SANTA MARGARITA RIVER BEACH OCEANSIDE, CALIFORNIA - 1949

BY

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INTRODUCTION

In the course of an oceanographic study by the University of California in conjunction with the U.S. Marine Corps, measurements and observations were made of waves, longshore currents, and beach conditions in the vicinity of the Santa Margarita River at Oceanside, California (Figure 1). These data, covering a period of ten months, are presented for the purpose of making available to the oceanographer and geologist the type of field information which is almost non-existent. To the authors' knowledge the only other published study of this type which presents data collected over a relatively long interval was made along-side the pier of the Scripps Institution of Oceanography (SHEPARD AND LAFOND, 1940).*

WAVE RECORDS

A thermopile wave meter (ISAACS AND WIEGEL, 1950) was used as the underwater pressure pickup unit. It consisted of a synthetic rubber bellows mounted on a plastic base with an encased thermopile. The hot junctions of the thermopile were in contact with the air in the bellows, while the cold junctions, insulated from the air chamber in the bellows, were in thermal contact with the surrounding sea water. The pickup unit, located approximately forty-two hundred feet offshore in about forty-three feet of water below Mean Lower Low Water, was connected by a submarine cable to a commercial recording self-balancing potentiometer which was located on shore.

In addition to the automatically recorded wave characteristics, obtained for two weeks in March, 1949, and then almost continuously from May through the middle of January, 1950, observations were made of the angle the breakers made with the beach, thus giving a fair indication of the wave direction. Because of the location of Santa Margarita River Beach, about the only waves of any significance came from a small sector due West, or from a southerly direction, with the exception of those from near-coastal storms. (TODD and WIEGEL, 1952)

The records, analyzed for a twenty to thirty minute interval every eight hours, are presented in Figure 2. The primary data are the average wave period and the "unrefracted" deep water height of the highest one-third of the waves, the so-called "significant waves". The term "unrefracted" wave height refers to the height the waves would have had in deep water if unaffected by refraction, and it is related to the height in transitional water (WIEGEL, 1953) by the following equation (HYDROGRAPHIC OFFICE, 1944 and WIEGEL, 1948):

$$H'_o = H/\sqrt{C_o / 2nC} \qquad (1)$$

where $C_o/C = 1 \tanh (2\pi d/L)$ and $n = \frac{1}{2}\left[1 + \frac{4\pi d/L}{\sinh (4\pi d/L)}\right]$

H = wave height at location of wave meter

* See Bibliography

H_o' = unrefracted deep-water wave height

C = wave velocity

C_o = deep water wave velocity

L = wave length

d = water depth

The wave steepness also is presented in Figure 2, as laboratory studies have indicated that it is this wave characteristic which is most closely related to the phenomena of changes in beach profile and the movement of sand onto and off of beaches (BEACH EROSION BOARD, 1936; JOHNSON, 1949; and SAVILLE, 1950). The steepness is the ratio of the unrefracted deep-water wave height to the deep-water wave length, H_o'/L_o, where the deep-water wave length is given by the following equation:

$$L_o = gT^2/2\pi \qquad (2)$$

where L_o = deep water wave length

g = acceleration of gravity

T = wave period

In Figure 3 data on breaker conditions are presented. The directions are visual observations, made almost daily excepting weekends. Data for both primary and secondary trains (if present) are shown. It is emphasized that the breaker direction is not necessarily the same as the deep water wave direction, due to the effect of refraction (See sketch at the bottom of Figure 3). With the exception of the visual observations presented for the month of April, the breaker heights were computed from the records of the Thermopile Wave Meter with the use of empirical curves (HYDROGRAPHIC OFFICE, 1944). Subsequent laboratory studies have shown, however, that the breaker height depends upon the beach slope as well as the wave characteristics; however, for the slope of the beach under discussion (about 1:30), the original empirical data are effectively the same as the latest published data (IVERSEN, 1952)

In Table I are presented the times that the deep water wave heights, the average periods, the wave steepnesses, and the breaker heights and directions were within certain ranges of values. It can readily be seen that unrefracted deep-water heights were rarely above four feet and the breakers rarely above six feet. Most of the predominant waves (i.e., the "primary" trains) were from a southerly direction.

LONGSHORE CURRENTS

Observations of the longshore currents were made nearly every week day during a large part of the time. This was done by throwing a small package of dye into the surf and measuring the distance the dyed water moved in one minute (about the maximum length of time the dye could be traced before it dispersed almost completely). The data on magnitude and direction are shown in Figure 3 and are presented in Table I as the time the measurements were within certain ranges of values. It can be seen that the direction of longshore movement generally corresponded to the direction of the primary trains of breakers. On a few occasions, however, the direction corresponded to the direction of the secondary train. This was because the magnitude of the longshore current depends directly upon the breaker height, but inversely with the period; thus, the short period waves from the near-coastal storms were sometimes more important than the larger long-period waves coming from another direction, insofar as longshore currents are concerned. (PUTNAM, MUNK and TRAYLOR, 1948; INMAN and QUINN, 1951)

BEACH CONDITIONS

The interaction of the ever varying surf and the material of which a beach consists causes constantly changing beach conditions. In order to obtain data on this phenomenon, beach profiles were taken at about two week intervals (Figure 5). Range lines were established along the beach as shown in Figure 4; however, only ranges 7 + 50, 12 + 50 and 17 + 50 were used continuously. The method of obtaining profiles through the surf by means of a DUKW and leadline has been described elsewhere (PATRICK, 1952). In addition, samples of sand were analyzed for mechanical size distribution and mineralogical content (Figure 7).

There are basically three types of beach changes. The first is the long-range change which dpends upon changing sand supply and changing meteorological conditions. The second is the seasonal change due to long intervals of high surf during "winter" meteorological conditions, long intervals of low surf during "summer" meteorological conditions, and increased sand supply from flooding rivers. The third is the short time change due to rapidly changing surf conditions, such as when a near-coastal wind generates short high waves during a period of normally long low waves.

The data have been presented in two figures. In Figure 5 are presented the profiles, measured to a depth of about twenty-five feet below Mean Lower Low Water. In Figure 6 are shown (using a larger scale) the profiles of the beach face.

It can be seen that, in general, the width of the berm increased during the summer months and decreased during the winter months. However, the three sets of profiles were not consistent. For example, considerable sand was deposited on the beach face on Range 7 + 50 between 2 September 1949 and 16 September 1949, while erosion took place between 16 September and 29 September 1949; on Range 12 + 50 a slight amount of erosion occurred between 2 September and 16 September 1949 as well as between 16 September and 29 September 1949; and, on Range 17 + 50 there was some slight deposition between 2 September and 16 September 1949 and some slight deposition between 16 September and 29 September 1949. Some of these apparent discrepancies can be explained by the presence of cusps on the beach during some periods of time; thus, one profile may be across the ridge of a cusp, while another across the hollow of a cusp. This condition makes it very difficult to obtain an accurate picture of what is happening unless a large number of ranges are surveyed. Certain changes were of such a magnitude, however, that they were observed along all three ranges; for example, between 12 December 1949 and 21 December 1949 a near-coastal storm occurred and severe erosion took place along the entire beach, and a pronounced scarp was formed.

One point appears of interest, although there is an unfortunate lack of data, that is the increase of sand on the beach face during January. It will be noted that in January 1949 on Range 7 + 50 and in January 1950, on Range 12 + 50 (the only ranges which were sounded) there was a seaward building of the beach face. It will be further noted that during January 1950 the waves were very low. Unfortunately there were no wave measurements made during January 1949.

The three series of offshore profiles were more consistent than were the series of onshore profiles. It can be seen that although a distinct bar was often lacking, there usually was a step present, but almost never was there a time when neither bar nor step was present. It can further be seen that although the profiles were constantly changing, they were always within rather remarkably narrow limits. The total vertical variation at any distance offshore was always less than plus or minus four feet from the mean. It appears as if the beach never reaches an equilibrium condition in the true sense of the word, but rather is in dynamic equilibrium.

Because of the relationship between wave steepness and beach profile found in laboratory work (BEACH EROSION BOARD, 1936; JOHNSON, 1949; and SAVILLE, 1950) a similar relationship was sought from these data. Although no definite relationship was found, it is believed that the two week intervals between profiles was so large that adequate data were not available.

The laboratory studies have shown that for waves steeper than 0.03 the "storm" profile existed (that is, a bar formed), and for values less than 0.025 no bar was present, while for values of wave steepness in between the profiles were unstable. It is readily apparent that this is not the case in the data measured at Santa Margarita River Beach. In fact, the wave steepness never came near the critical value of 0.03 and a bar or a step usually was present. The greatest wave steepness measured was about 0.008 and it was seldom above 0.003. If the criteria are correct, then the reason they do not seem to apply to natural beaches may be: (1) the beach is never in equilibrium, or (2) the waves in nature are quite variable and the highest during a storm may well be steeper than the values shown, which are those of the "significant" wave.

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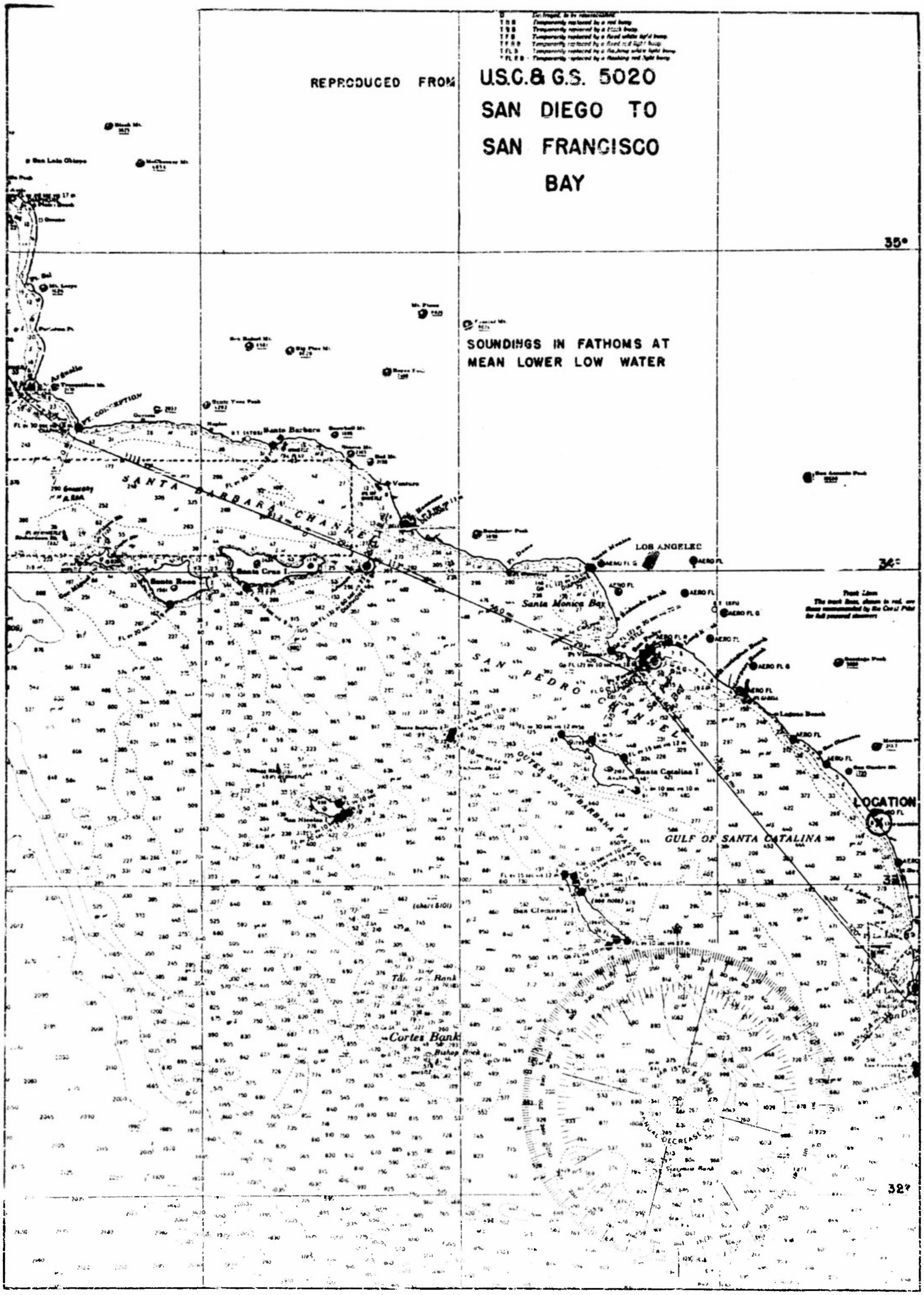
TABLE I.

MEASURED AND OBSERVED WAVE AND LONGSHORE CURRENT CHARACTERISTICS.

	Range	1949 Mar. 8-22	1949 28 Mar-30 Apr	1949 May	1949 June	1949 July	1949 Aug.	1949 Sept.	1949 Oct.	1949 Nov.	1949 Dec.	1950 1-16 Jan.
$(H_o')1/3$ (feet)	0-2	40	--	77	64	69	85	76	87	89	97	93
	2-4	50	--	23	36	31	15	24	13	11	3	7
	4-6	10	--	0	0	0	0	0	0	0	0	0
$T_{ave.}$ (Seconds)	< 9	0	24	7	7	0	0	0	0	0	7	19
	9-11	29	12	19	7	3	7	0	3	0	14	25
	11-13	29	4	26	36	35	19	24	3	35	45	19
	13-15	21	40	44	46	38	55	45	55	50	31	19
	> 15	21	20	4	4	24	19	31	39	15	3	18
$(H_o')1/3/L_o$	< .001	0	--	4	0	3	11	14	19	22	61	69
	.001-.002	20	--	62	50	62	67	69	71	78	25	31
	.002-.003	30	--	18	36	24	11	17	6	0	7	0
	.003-.004	30	--	4	4	16	4	0	0	0	4	0
	.004-.005	10	--	4	10	0	4	0	0	0	3	0
	> .005	10	--	8	0	0	4	0	4	0	0	0
$(H)_B$ 1/3 (feet)	0-2	7	8	0	0	0	6	0	1	12	59	91
	2-4	29	76	80	69	64	74	69	74	69	38	9
	4-6	36	16	20	30	36	19	20	25	19	2	0
	6-8	21	0	0	1	0	1	11	0	0	1	0
	> 8	7	0	0	0	0	0	0	0	0	0	0
Primary Breakers Direction	WNW	--	4	0	0	0	0	0	0	--	--	--
	W	--	12	0	0	0	0	0	14	--	--	--
	WSW	--	39	28	35	0	0	0	43	--	--	--
	SW	--	5	67	61	89	93	100	43	--	--	--
	SSW	--	0	5	4	11	7	0	0	--	--	--
Littoral Current Magnitude (Knots)	0-0.2	--	33	55	63	50	33	9	57	--	--	--
	.2-0.4	--	33	18	25	33	45	18	29	--	--	--
	.4-0.6	--	34	9	0	17	22	18	14	--	--	--
	.6-0.8	--	0	9	17	0	0	27	0	--	--	--
	> 0.8	--	0	9	0	0	0	27	0	--	--	--
Littoral Current Direction	N-S	--	83	42	27	7	10	45	75	--	--	--
	S-N	--	17	58	73	93	90	55	25	--	--	--



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SAN DIEGO TO
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BAY
SOUNDINGS IN FATHOMS AT
MEAN LOWER LOW WATER
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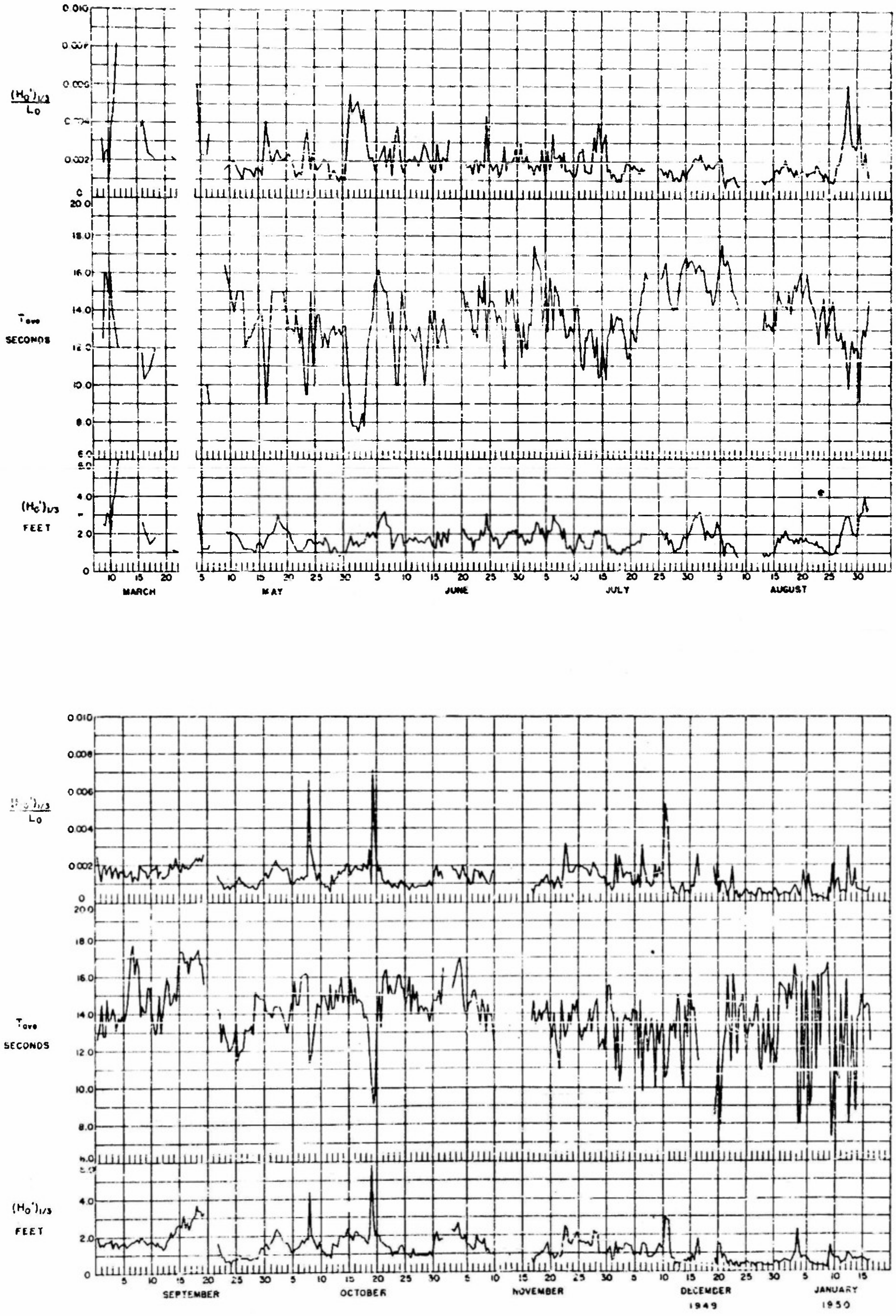
34°
33°
32°
SANTA BARBARA CHANNEL
Santa Barbara
Santa Cruz I
Santa Rosa
Santa Monica Bay
LOS ANGELES
SAN PEDRO CHANNEL
Santa Catalina I
OUTER SANTA BARBARA PASSAGE
GULF OF SANTA CATALINA
San Nicolas I
San Clemente I
Cortes Bank
LOCATION

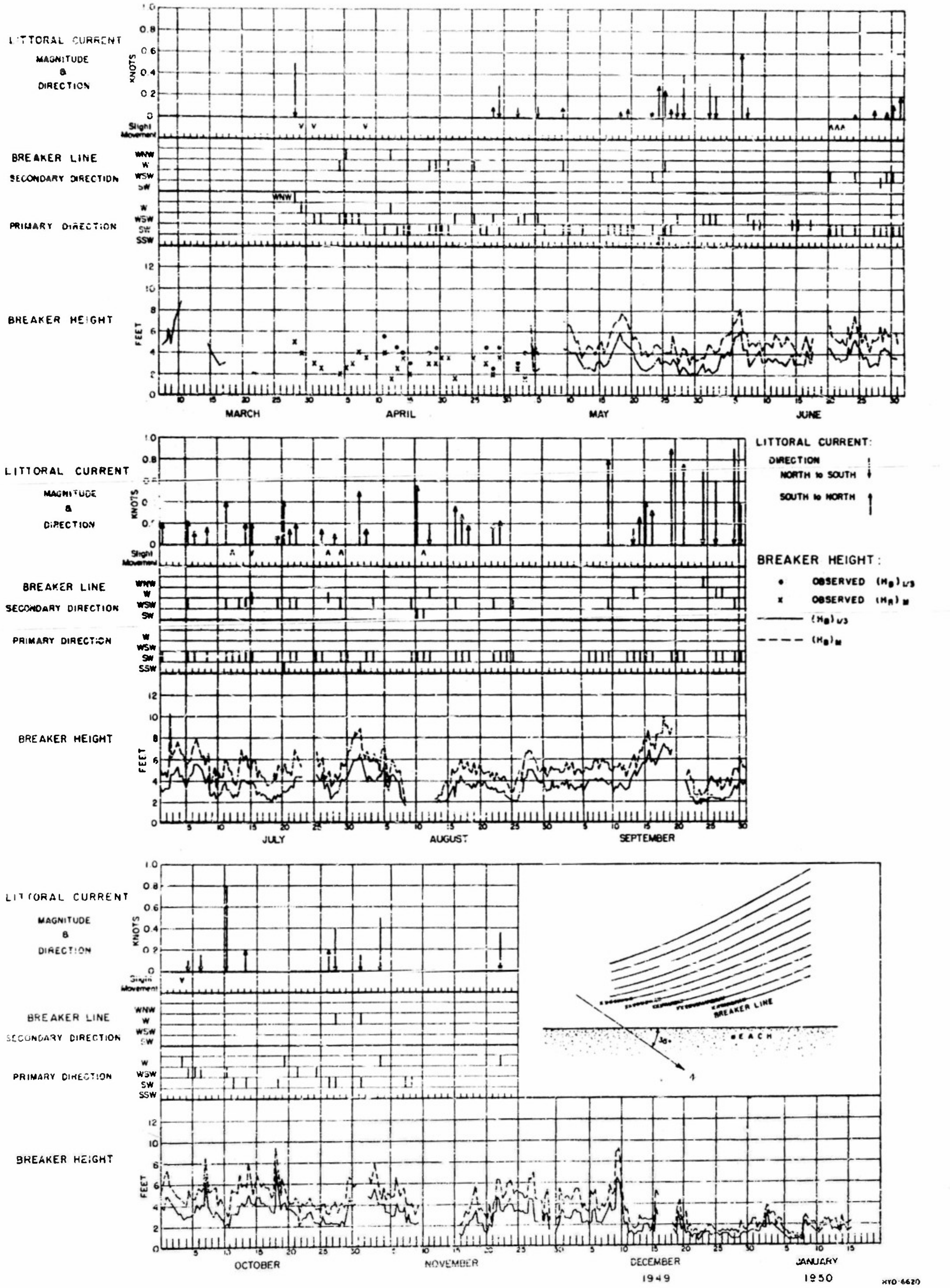
FIGURE 1



"UNREFRACTED" DEEP WATER WAVE HEIGHT, PERIOD, STEEPNESS

SANTA MARGARITA RIVER BEACH, OCEANSIDE, CALIFORNIA

FIGURE 2

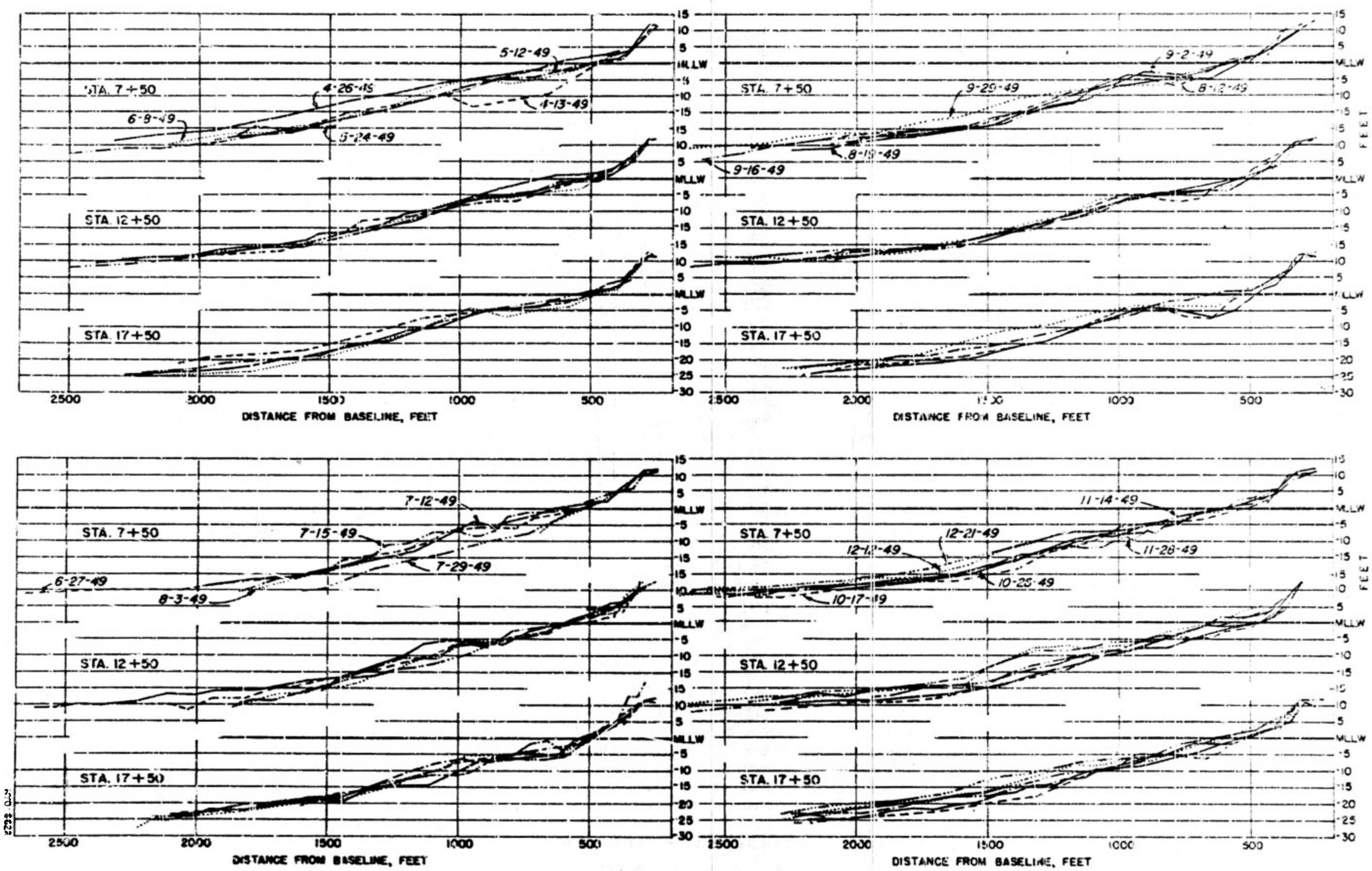


BREAKER HEIGHT AND DIRECTION; LITTORAL CURRENT DIRECTION AND MAGNITUDE
SANTA MARGARITA RIVER BEACH, OCEANSIDE, CALIFORNIA

FIGURE 3

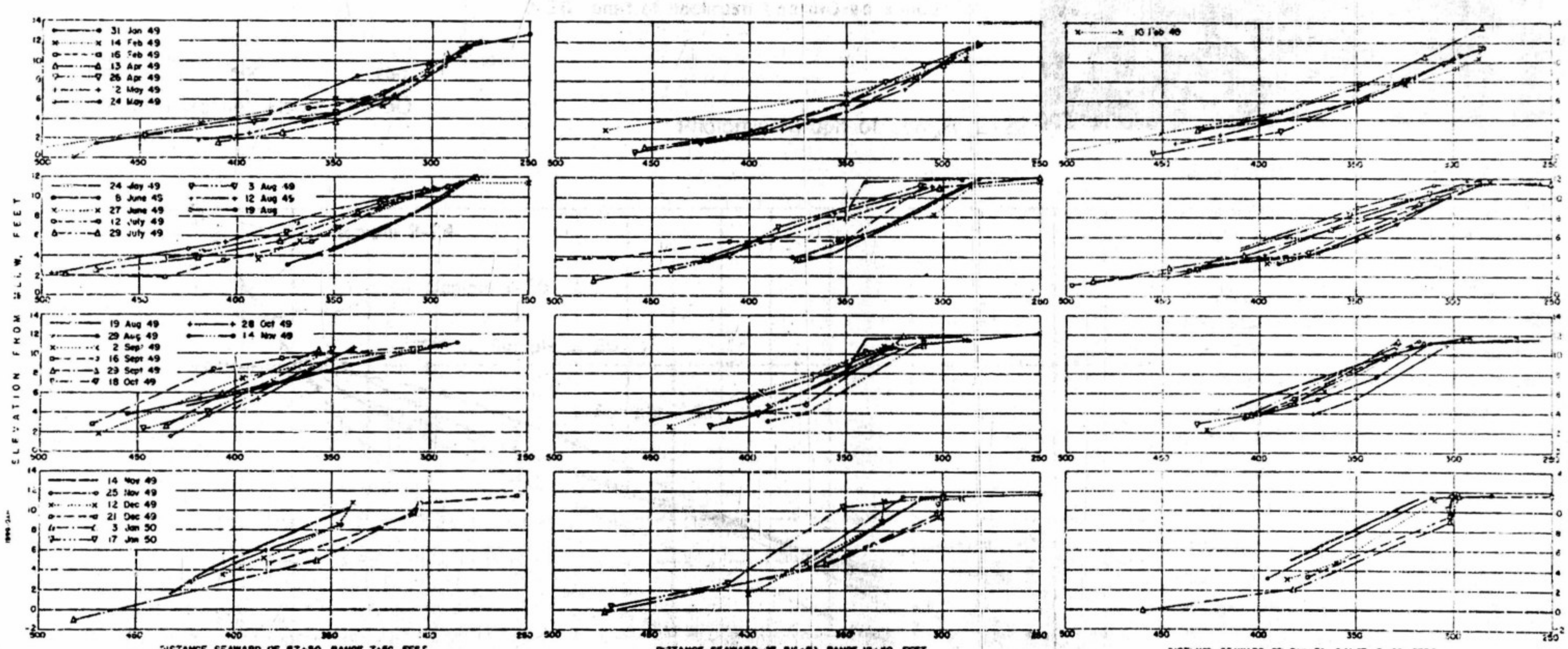
Aerial photograph of operating area,
Santa Margarita River Beach, Oceanside, Calif.

FIGURE 4



BEACH PROFILES, SANTA MARGARITA RIVER

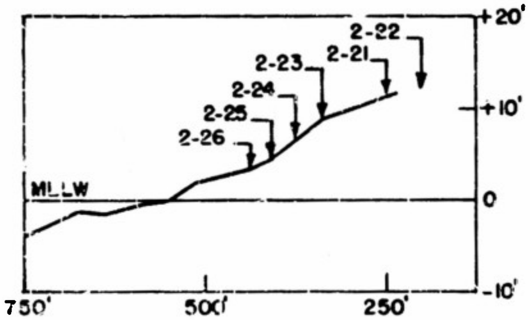
FIGURE 8



BEACH FACE PROFILES, SANTA MARGARITA RIVER BEACH

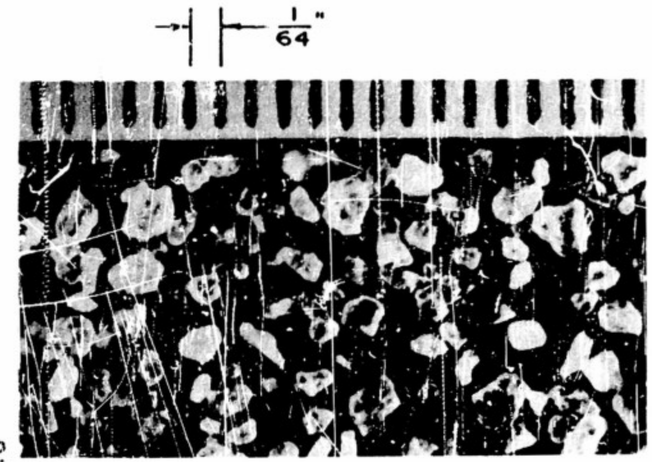
OCEANSIDE, CALIFORNIA — 1949

FIGURE 6

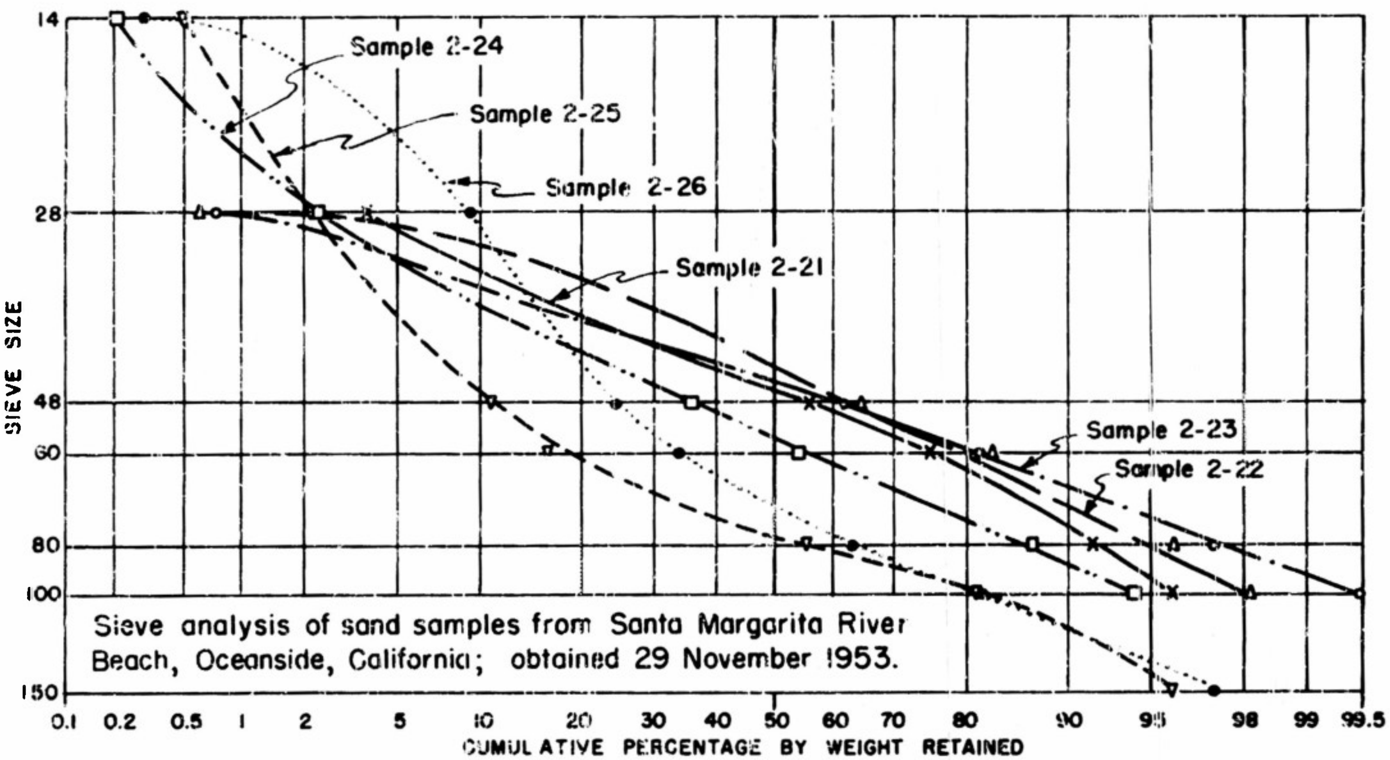


Beach profile, Range 7+50

2-21 - on berm (sand moist after rains)
2-22 - at edge of permanent vegetation
2-23 - at seaward edge of berm
2-24 - at limit of high tide uprush (moist sand)
2-25 - limit of uprush (wet sand)
2-26 - limit of backrush (saturated sand)



Photomicrograph of sample 2-22



Sieve analysis of sand samples from Santa Margarita River Beach, Oceanside, California; obtained 29 November 1953.

Mineralogical analysis of sample 2-24:

Mineralogy - 0.5% by weight of this sample consisted of strongly magnetic minerals. Of the remainder 55% quartz, 20% feldspar, 8% tourmaline, 5% hornblende, 3% sphene, 3% chlorite, 2% hypersthene, 2% epidote, 1% kyanite, 1% unidentifiable rock fragments, and traces of staurolite, biotite and glaucophane.

Roundness - 0.4

Sphericity - 0.6

Density - 2.62

Sorting - good as to size, fair as to shape, poor as to kind.

Color - light grayish tan.

ANALYSIS OF BEACH SAND

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